Fermi National Accelerator Laboratory

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Hadronic Final States in 490 GeV Muon Deep Inelastic Scattering *

The E-665 Collaboration

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HADRONIC FINAL STATES IN 490 GEV MUON DEEP INELASTIC SCATTERING

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ABSTRACT

Hadronic final states from 490 GeV muon interactions on H_2, D_2 and Xe targets have been studied. Jet physics and inclusive K^0 production results are presented. 2-forward jet events in deep inelastic scattering can originate from gluon bremsstrahlung and from photon-gluon fusion. Evidence for jet structure consistent with QCD predictions is seen. Inclusive K^0 production is studied and some preliminary results are given.

1. Introduction

E665 uses the highest energy muon beam yet achieved at a particle accelerator to study deep inelastic scattering (DIS). This higher beam energy allows new regions of kinematics to be explored. The experiment is described in detail elsewhere[1]. The spectrometer was designed and built to maximize the detection and identification of hadrons originating in deep inelastic scatters of muons. The spectrometer consists of two parts – the vertex spectrometer, built to detect slow particles (backward in the center-of-mass (CM) system) and the forward spectrometer designed to detect fast particles. The analysis topics covered below use the forward spectrometer only.

2. Jet Production

Deep inelastic scattering in the quark-parton model (one-photon exchange) can be represented by the diagram in Figure 1(a). Lowest order QCD corrections to the quark-parton model give contributions from gluon bremsstrahlung and from photon-gluon fusion (Figure 1(b)). The QCD contributions are predicted to increase with increasing center-of-mass energy W of the virtual photon-nucleon system[2]. These contributions are expected to manifest themselves in planar events with energy flow characteristic of 2-jet structures in the forward hemisphere.

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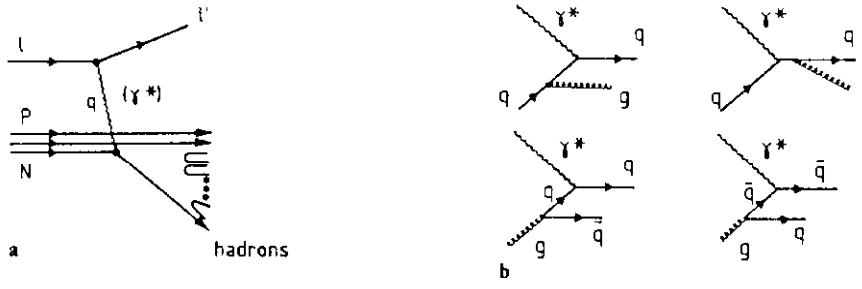

Figure 1

E665, having larger center of mass energy and a spectrometer for detecting forward hadrons, is better suited to study jets in DIS than previous, lower energy experiments. In addition, the photon-gluon fusion term is not present in other physics collision processes which study jet production and is therefore interesting to study in DIS (or real photoproduction).

The data sample used for the jet analysis consists of the H_2 and D_2 data from the 1987-88 Fermilab fixed-target run. The following kinematic cuts were used to isolate an event sample enriched in 3-jet events:

$Q^2 > 3.0$ GeV^2
$x_{Bj} > 0.003$
$60 < \nu < 500$ GeV or W > 20
$0.1 < y_{Bj} < 0.85$

Two complementary analyses have been performed. One approach emphasizes the events with high charged multiplicity and the study of energy flow and planarity[3,4]. The other analysis utilizes both charged and neutral electromagnetic energy at high W.[5] The two analyses give consistent results. The plots shown here come from the second analysis. The W cut forces the data to low x_{Bj} (= $Q^2/2m\nu$). The x_{Bj} distribution peaks at 0.008.

Monte Carlo techniques are relied upon to study and disentangle the effects coming from structure functions, fragmentation, and parton-level diagrams and to make corrections for the acceptance of the spectrometer. Five variants of the Monte Carlo were used in the figures to follow.

1. LUND 4.3, Morfin-Tung parton distributions[6], no soft gluons.
2. LUND 4.3, Gluck-Hoffman-Reya parton distributions, soft gluons.
3. LUND 4.3, Gluck-Hoffman-Reya parton distributions, no soft gluons.
4. LUND 4.3, no hard QCD.
5. LUND 4.3, no hard QCD, increased fragmentation p_t (0.7 GeV/c).

Three quantities are plotted to show the effects of QCD. Figure 2 shows the average p_t^2 as a function of x_F for $x_F > 0$ where p_t^2 is calculated with respect to the virtual photon direction. Figure 3 shows $p_{t,in}^2$ and $p_{t,out}^2$ of the hadronic event plane formed by minimizing the p_t^{out} for each event. Figure 4 shows the energy flow projected onto the event plane around the virtual photon direction after a

jet-reconstruction algorithm[4] has been applied and the highest energy jet has been placed to the left of the photon direction.

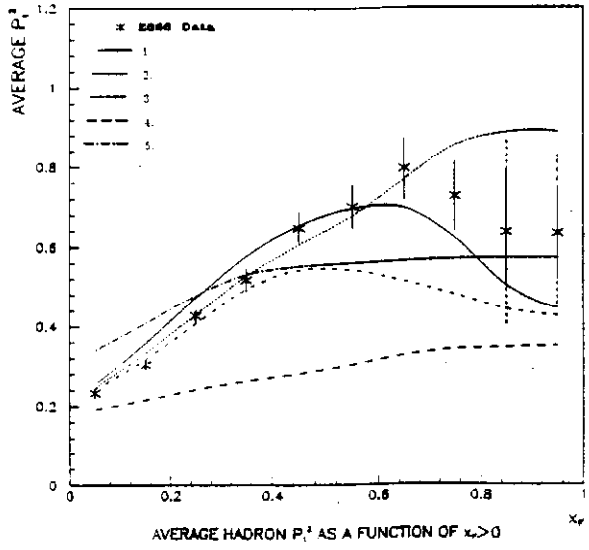

Figure 2

Taken together the plots indicate that QCD is necessary to fit the data. The separation and understanding of the contributions to the effects seen from the gluon bremsstrahlung and from the photon-gluon fusion diagrams is being studied. It will be very important to be able to study and separate the effects that can be attributed to the basic QCD diagrams and which can be attributed to fragmentation. Data exist in kinematic regions where photon-gluon contributions may make up an appreciable fraction of the cross section. We therefore hope that a constraint on the gluon distribution at low x_{Bj} ($0.005 < x_{Bj} < 0.05$) can be made using this technique.

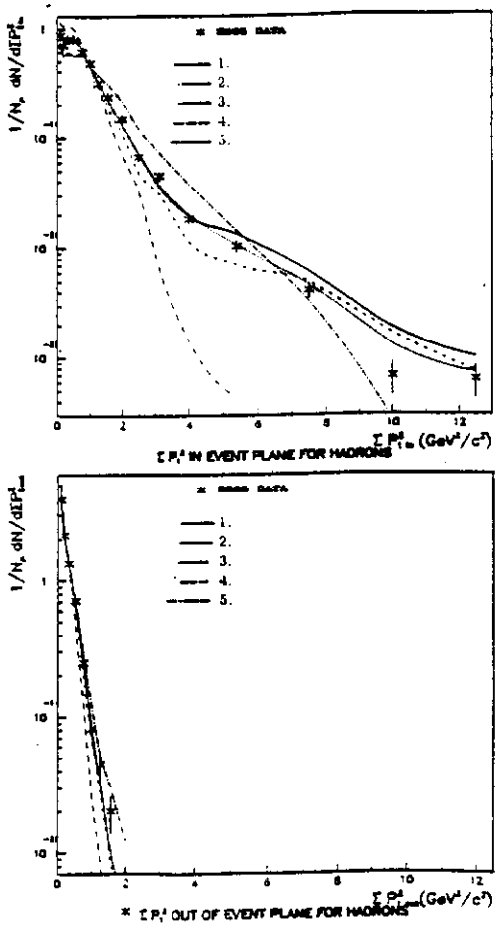

Figure 3

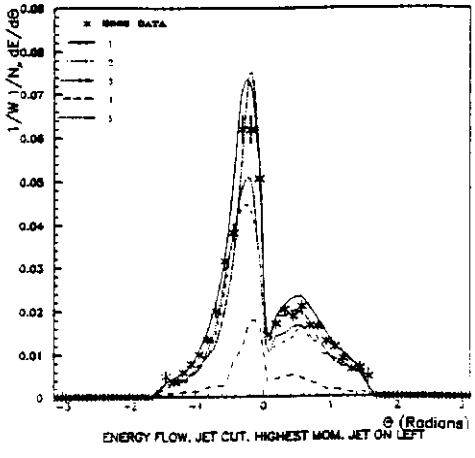

Figure 4

3. Inclusive K^0 Production

One of the goals of measuring K^0 production in E665 is to extend the study of strangeness production to higher energy in DIS. The data samples studied include all of the D_2, H_2 and Xe data from the 1987-88 run. The following cuts are made on the data sample to exclude kinematic regions where radiative corrections are potentially large.

$$x_{Bj} > 0.003$$
$$0.1 < y_{Bj} < 0.8$$

To isolate K^0_s decays the candidate kaon decay is required to be more than 2σ from the primary vertex ($L/\sigma_L > 2$). In addition, photon conversions to $e^+ e^-$ pairs are removed by a requirement that the invariant mass of the 2 charged tracks be greater than 50 MeV/c^2. A signal and two background regions are established for the K^0_s. The signal region is $475 < M_{\pi^+\pi^-} < 525$ MeV/c^2 and the 2 background regions are $450 < M_{\pi^+\pi^-} < 475$ MeV/c^2 and $525 < M_{\pi^+\pi^-} < 550$ MeV/c^2. The Xe K^0_s signal is shown in the inset to Figure 5. The number of K^0_s's found in the D_2, H_2 and Xe samples are 858, 228, and 235, respectively.

The final distributions are generated by background subtraction, corrected for acceptance using background-subtracted Monte Carlo, and corrected for the $K^0_s \to \pi^+\pi^-$ branching ratio and undetected K^0_L's

Figure 5 shows the x_F distribution of inclusive K^0 production on D_2. The errors shown are statistical only. Figure 6 shows the z distributions for the three targets H_2, D_2 and Xe. They all agree with each other within statistics.

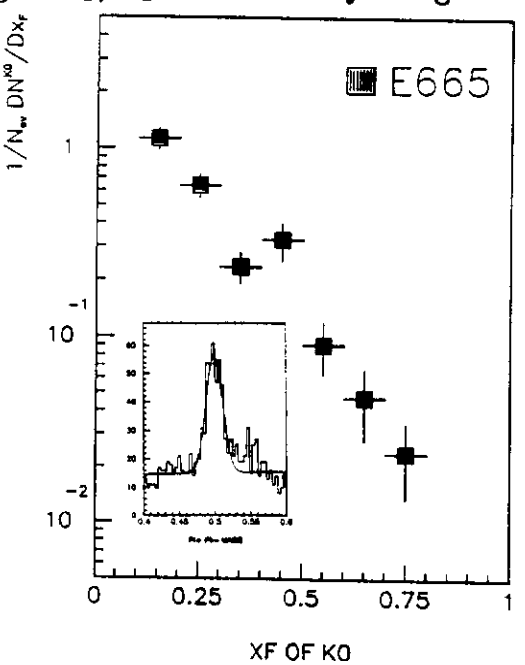

Figure 5

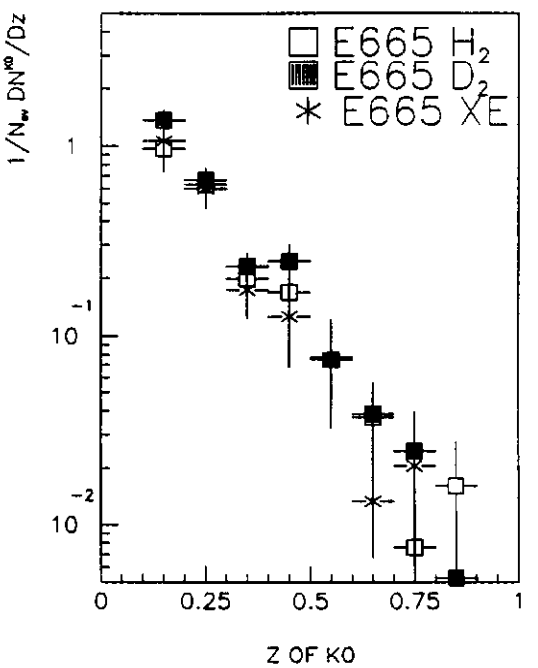

Figure 6

In conclusion, we see K^0 production in the forward region which falls as a function of x_F in a manner qualitatively similar to the dependence of inclusive π production but which has a substantially lower yield as expected.

4. Conclusions and Prospects

E665 has observed both jet production and K^0 production in DIS at 490 GeV/c. These results and other not presented include the following topics:

- Jet physics
- Multiplicity distributions
- Inclusive K^0 production
- Exclusive ρ^0 production
- Inclusive π^0 production
- Bose-Einstein correlations
- Xe and D_2 hadronic distribution comparison
- Hadron formation length in fragmentation

These permit E665 to perform a comprehensive study of the hadronic final state in lepton scattering at the highest energies currently available. The 1990 run just completed took data on more targets (H_2, D_2, C, Ca, Pb) and with improved tracking, extending the acceptance to lower x_F. The 1991 run will concentrate on light targets (H_2 and D_2) and much increased statistics on those targets.

References

1. M. Adams, *et al.*, Nuclear Instruments and Methods **A291** (1990) 533.
2. G. Altarelli and G. Martinelli, Phys. Lett. **76B** (1978) 89.
3. H. Lubatti, "Energy Flow and Transverse Momentum of Hadron Jets Produced in Deep Inelastic Muon Scattering", Proceedings of the XXV International Conference on High Energy Physics, Singapore, 1990.
4. D. Jansen, " Energy Flow and Azimuthal Asymmetry of Charged Hadrons Produced in 490 GeV/c Deep Inelastic Muon Scattering", PhD. Thesis, University of Washington, (in preparation).
5. D. Michael, "A Study of Transverse Momentum and Jets Using Forward Hadrons and Photons in Deep Inelastic Muon Scattering at 490 GeV/c", PhD thesis, Harvard University, April, 1990.
6. Jorge G. Morfín and Wu-Ki Tung, FERMILAB-Pub 90/74, April, 1990 (Submitted to Z.Phys.C).